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THIS TEACHER'S GUIDE FOR A UNIT ON ASTRONOMY ESTABLISHES (1) UNDERSTANDINGS AND ATTITUDES, (2) SKILLS, AND (3) CONCEPTS TO BE GAINED IN THE STUDY. THE OVERVIEW EXPLAINS THE ORGANIZATION AND OBJECTIVES OF THE UNIT. TOPICAL DIVISIONS ARE (1) THE EARTH, (2) THE MOON, (3) THE SUN, (4) THE SOLAR SYSTEM, (5) THE STARS, (6) THE UNIVERSE, AND (7) SPACE EXPLORATION. A VOCABULARY LIST, BIBLIOGRAPHY, TESTS, CHARTS, AND A LIST OF STUDENT ACTIVITIES COMPRISE THE MATERIAL. MOST OF THE FACTUAL PRESENTATION IS IN QUESTION AND ANSWER FORM. THE ANNOTATED BIBLIOGRAPHY IS CODED TO INDICATE THREE LEVELS OF DIFFICULTY. THE CONCLUDING SECTION LISTS DEMONSTRATIONS, FILMS, AND FILMSTRIPS. (DH)

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ASTRONOMY

LOUISIANA ARTS AND SCIENCE CENTER

ASTRONOMY

Objectives for Astronomy Unit

A. Understandings and attitudes

1. To understand and appreciate the smallness of the Earth and the vastness of the universe.
2. To increase curiosity in the realm of space.
3. To understand why it is said that we are in the Space Age.
4. To realize how little man knows of the space surrounding his world.
5. To acquire a sense of excitement and pride in being part of an age embarking upon a New Frontier.
6. To learn the basic laws that affect all bodies in the universe.
7. To acquire a knowledge of the earth and the various bodies in the universe.
8. To use original thinking in the solving of problems.

B. Skills: The students participating in the various activities of this unit should have increased their skill in:

1. Locating many sources of information
2. Interpreting and recording information.
3. Increasing their vocabulary, speaking clearly, and giving information in an interesting manner when communicating with others.
4. Listening.
5. Reading the newspapers and periodicals for current information on specific subjects.
6. Making evaluations from known specific facts.

Concepts

1. Our earth is part of the sun's family known as the Solar System.
2. Our knowledge of the earth helps us to understand the other members of the Solar System.
3. Earth revolves around the sun and rotates on its axis.
4. Time and climate on Earth is dependent upon the Earth's position relative to the sun.
5. Every particle of matter attracts every other particle of matter by the force of gravitation. The larger the particle the greater the force. However, the force becomes less as the distance between the particles becomes greater.
6. Gravitational force holds the earth, moon, planets, and other objects of the Solar System in their orbits, and is responsible for tides and the retention of an atmosphere.

7. The Solar System consists of the planets and their satellites, comets, meteors, and the asteroids, which all revolve around the sun.

8. The planets are divided into two groups, the smaller ones which are closer to the sun and the giant planets which are far away from the sun.

9. The period of revolution of the planets increases as the distance from the sun increases, but their orbital velocities decrease.

10. Venus, Mars, and Earth have many things in common.

11. Neptune, Jupiter, and Saturn are giant planets.

12. Pluto seems to be out of place in the orderly solar system.

13. It is doubtful that there is life as we know it on any planet except Earth in our Solar System.

14. Our knowledge of the moon is increasing every day.

15. The moon station will be a great advantage to us in our space exploration.

16. It is supposed that life on the moon would be very different from life on earth.

17. Our sun is a medium-size star.

18. Millions of stars are found in one galaxy and they vary in brightness.

19. Stars' apparent brightness or magnitude depends upon size, temperature, radiation, and distance.

20. The Milky Way is the name of our galaxy.

21. There are infinite numbers of galaxies in the universe. Each galaxy has a different shape.

22. The universe is composed mainly of empty space.

23. The objects in the universe all seem to be rushing away from each other.

24. There are many theories about the origin of the universe and Solar System.

25. Man, in the beginning of the Space Age, has many problems to solve in space travel.

26. The next decade will increase our knowledge of the universe.

27. There are probably other planets in the universe which are similar to Earth.

Overview

It is hoped that this unit on astronomy will offer the student not only a knowledge of the many facts that are known about the heavens today but, more importantly, a sense of excitement and pride in being a part of the space age today.

The unit is divided into seven parts: (1) the earth; (2) the moon; (3) the sun; (4) the solar system; (5) the stars;

(6) the universe; and (7) our space explorations. The content material is given in question and answer form to enable the teacher to use these questions for class discussions or for worksheets for research if she desires. No one book was used in compiling the information but if you wish to suggest books for the students' use, you might use World Book Encyclopedia, Volumes 1, 13, and 17, and the Roy Gallant books, Exploring the Universe, Exploring the Planets, Exploring the Earth, and Exploring the Moon.

Also included in this unit are a vocabulary list, a bibliography, tests, that you can either expand or omit entirely as you see fit, charts, and a list of student activities that can be used to develop individual ability.

A representative from the Arts and Science Center will come to give a demonstration or introductory lesson to the class in connection with this unit of study. At this time she will bring some of the special equipment for use specifically with this unit.

It is hoped that the class will benefit greatly from a field trip to the Center's new planetarium. Please call the Louisiana Arts and Science Center for a reservation for your class visit to the Planetarium.

Introduction

Concepts

The universe is extremely large and difficult to understand when considered in earthly distances.

The revolution of a planet is its trip around the sun.

The rotation of a planet is its spin around an imaginary axis.

You might begin by having the child present his discussion as though in reply to a letter he has received. U.S.A., Western Hemisphere, and planet Earth might be the topics reviewed. Explain what each of these mean, using a globe to show the areas. Then ask the students if they know any other terms that we must add to the discussion as we think of ourselves as part of the universe. Then add Solar System, Milky Way Galaxy, Local Group, Universe. Draw a large circle on the board to represent the universe, and draw galaxies throughout. Have some of the galaxies in groups. Now explain to the class our relationship in this large picture.

To give the student some concept of how vast space is and how many stars are involved, these facts are helpful:

1. If we named every star in the Milky Way, naming one a second, it would take us 4,000 years.

2. Alpha Centauri, our nearest star, is four light years away.

3. Our Sun with its system of planets is about 30,000 light years from the center of the galaxy.

4. The cup of the Big Dipper contains 300 galaxies.

Tell the class that during their lifetime man will explore the first of these space systems, our solar system. Show them the model solar system, explaining how the sun is the center, and showing them the meaning of the terms rotation and revolution. Make sure that they understand these terms by asking them to point to parts of this solar system which are used in demonstrating these concepts. Explain to them how the planets have longer years as their distance from the sun increases. Show this on the model. The rotation of the planets causes day and night, the equatorial bulge and with the law of gravitation--the tides.

Conclude by giving the children matching statements involving rotation and revolution.

1. I am thirteen years old. (Revolution)
2. The days on Jupiter are much shorter than the days on Earth. (Rotation)
3. The year on Mars is about twice as long as an earth year. (Revolution)
4. If a planet is rotating faster than Earth, is its day shorter or longer than ours? (Shorter)
5. If a planet's orbit is longer than Earth's, is its year longer or shorter than ours? (Longer)

6. Does a year on Mars have more days in it than a year on Earth? (Yes)

Materials used:
1. Solar System
2. Globe
3. Chalk and chalkboard
4. Chart of the Planets

The following are questions and answers for the teachers' use. The earth, the moon, the sun, the solar system, the stars, the universe, and our space program are touched on. The class may be given a copy of the questions and could be responsible for finding the answers to four or five questions each day. The class time could be spent in discussion and in viewing films and filmstrips that help answer questions or clarify further knowledge gained.

The Earth as Part of the Universe

Laws that hold true on the earth, hold true throughout the universe.

1. Give three proofs that the earth is round.

   a. The shadow of the earth on the moon is curved.
   b. Ships can be seen coming over the horizon or disappearing below it.
   c. Pictures taken by our space craft show curvature of the earth.

2. What is the shape of the earth?

   Although the earth is more round than a baseball, it is still somewhat pear-shaped.

3. What is the diameter of the earth?

   The diameter is 8,000 miles at the equator and approximately 8,000 less twenty-seven miles at the poles.

4. What is the circumference of the earth at the equator?

   It is approximately 24,000 miles. A point on the equator of the earth rotates 1,000 miles an hour.

5. What causes the slight bulge at the equator?

   The rotation of the earth causes the bulge.

6. The earth is divided into three main layers. Name them and tell what is probably to be found in each layer.

   a. Crust--sedimentary rock, limestone and sandstone, and igneous rock, granite and bedrock.
   b. Mantle--iron and magnesium.
   c. Core--iron and nickle in liquid form caused by extremely high pressure and heat.

7. Approximately how thick is each layer?

   The Crust-- two and one-half to twenty miles.
   The Mantle--1,800 miles.
   The Core--2,200 miles.

8. Where is the thinnest part of the earth's crust found?

   It is at the ocean bottom which, as yet, has made it impossible for man to drill through the crust.

9. What is Operation Mohole?

   This project is an attempt to drill through the earth's crust at its thinnest point. The project has recently been abandoned by the United States government for the present.

10. What are the three main layers of the earth's atmosphere called?

    Troposphere, stratosphere, and ionosphere are the names of the three main layers of the earth's atmosphere.

11. How does each help life on earth?

    The troposphere carries our weather, and keeps the earth warm by trapping infra-red rays.
    The stratosphere contains ozone; it traps gamma rays, and keeps these harmful and dangerous rays from striking the earth. Jet planes fly in this layer of air.
    The ionosphere traps radio waves; satellites are orbited in this layer.

12. What gases or other substances make up our atmosphere?

    The gases found are nitrogen, oxygen, water vapor, and hydrogen. Dust particles are also found.

13. What is the cause of twilight?

    The atmosphere, troposphere, causes light from the sun to scatter so that light remains after the sun has set.

14. Define equator.

    The equator is an imaginary circle around the middle of the earth equidistant from North and South pole.

15. What are lines of latitude?

    Lines of latitude are imaginary circles parallel to the equator to measure north-south direction.

16. What are lines of longitude?

    Lines of longitude are imaginary circles drawn from north to south to measure west-east direction.

17. What is another name for latitude? For longitude lines?

    Another name for latitude is circles of parallel and the other name for longitude circles is meridians.

18. What is our unit of measure using these lines?

    Our unit of measure is degrees and its symbol is "o."
    There are 360° around the earth.

19. Using this unit of measure how far is it one-half the way around the world? Locate Baton Rouge.

It is 180°. Baton Rouge is 30° North and 90° West, approximately.

20. What is the Prime Meridian and where is it located?

It is located at 0° longitude and goes through the town of Greenwich, England. All distances are measured east and west of this line.

21. What is the only line of latitude that cuts the earth in half?

The equator is the only line of latitude that cuts the earth in half.

22. What is the Tropic of Capricorn? The Tropic of Cancer? Where is each located?

The Tropic of Capricorn is located 23½° South. It is an imaginary circle and is the greatest distance south of the equator at which the sun shines directly overhead.

The Tropic of Cancer is located at 23½° North. It is an imaginary circle and is the greatest distance north of the equator at which the sun shines directly overhead.

23. What is the Torrid Zone?

This very hot zone is located between the Tropic of Capricorn and the Tropic of Cancer.

24. Where are the Frigid Zones?

These are zones or areas located within the Artic and Anartic Circles above 66½° North and South.

25. Where are the Temperate Zones?

These zones are located between the Tropic and the Frigid zones.

26. What is the longitudinal circle of 180° called?

It is the International Date Line.

27. What is meant by the revolution of the earth?

This refers to the earth's journey around the sun. When the earth makes one complete trip it has made one revolution. One year has passed during this period of time.

28. How do we know that the earth revolves around the sun?

We know this by the apparent shift of the position of the stars. This is known as the parallax method.

29. Why did the Greeks 2,000 years ago fail in their attempts to prove this?

The ancient Greeks had no telescopes to see the stars' apparent movements. Therefore they thought the earth was stationary.

30. Explain rotation of the earth.

Rotation refers to the earth's spin on its axis. It rotates once in twenty-four hours.

31 What is the axis of the earth's rotation?

It is the imaginary line through the center of the earth around which the earth is rotating.

32, 33, 34. What is the earth's path around the sun called? What is its shape? How many times does the earth rotate in one period of revolution?

The earth's path around the sun is called its orbit. It is elliptical in shape. There are 365¼ rotations in one revolution.

35. Is the earth's spin slowing down? If so how much?

The earth's spin is slowing down about three hours per 2,000 year. Over the period of 2,000 years day will have become three hours longer than in the time of Christ.

36. In what direction is the earth spinning?

The earth is spinning from West to East.

37. What causes night and day?

Rotation of the earth causes night and day.

38. What is the scientist's definition of day?

The scientist's definition of day is twenty-four hours of time.

39. Why can't one tell that he is traveling?

One can't tell that he is traveling because everything else is traveling with him.

40. How many degrees is the earth tilted?

The earth is tilted at 23½°.

41. What are two reasons for the seasons?

Seasons are measured by the length of time the sun shines on the earth and the slant of the sun's rays.

42. How far away from Earth is the sun?

The Earth is 93,000,000 miles or 93×10^6 miles, mean distance, from the sun.

43. What is an astronomical unit?

One astronomical unit is equal to 93,000,000 miles. It is used to measure distances in interplanetary space.

44. Why is the earth divided into time zones?

The earth is divided into time zones for convenience.

45. Fifteen degrees of longitude is equal to how many hours?

15° of longitude is equal to one hour.

46. Into how many time zones is the United States divided? Name them.

The United States is divided into four time zones, Eastern, Central, Rocky Mountain, and Pacific.

47. Why do some time zones deviate?

    Political boundaries cause some time zones to deviate.

48. Define the term gravitation.

    Gravitation is the force of attraction between two or more particles in the universe, no matter how large or small. Force of attraction becomes weaker as distance increases between objects.

49. All other things being equal, which object has a stronger force of gravitation--a large object or a small object?

    A large object has the stronger force of gravitation.

The Sun

1. What color is the sunlight?

   It consists of all the colors in the rainbow.

2. What type of star is our sun?

   It is a medium-size yellow star.

3. Where does most of the heat from the sun go?

   Most of the heat is scattered into space.

4. How many earths would it take to make one sun?

   It would take more than one million earths to equal the size of our sun.

5. What are some of the things that the sun does for us?

   The sun provides us with heat, light, and radio waves. Students may expand on benefits of heat and light.

6. What is the principal gas found on the sun?

   Hydrogen is the principal gas found on the sun.

7. What causes the sun to continue giving off radiation?

   The sun is not burning in the usual sense. It is using the extra hydrogen atom that is left when hydrogen forms helium in the sun. This extra mass is converted into energy. This explanation is very simplified.

8. What are sun spots? Are they really dark?

   Sun spots are storms on the surface of the sun. They are really much brighter than we see them but appear darker than surrounding gases because they are cooler areas than the surrounding gases.

9. How do these sun spots affect us on Earth?

   They interfere with communication, they may affect electric storms on earth, and render compasses useless and therefore hamper navigation.

10. What are some of the different forms of radiation that the sun sends out?

It sends out X-rays, gamma rays, visible light, radio rays, and infra-red rays.

11. Is our sun moving through space?

Our sun is moving in an elliptical path in the galaxy and it rotates on its axis once in approximately every twenty-five days.

12. About how hot is the sun?

The sun is 11,000°F. at the surface and 36,000,000°F. in the center.

13. How heavy is the sun?

The sun is much lighter than the earth but its total weight is much heavier.
One cubic centimeter of water weighs 1 gram
One cubic centimeter of earth weighs 5.5 grams
One cubic centimeter of sun weighs 1.4 grams
so per cubic centimeter the sun is lighter than the earth (this is called density). But, as there is 332,958 times much more matter in the sun than in the earth, the whole sun is much heavier than the whole earth.

The Solar System

1. What is the Solar System?

The solar system is the sun with its family of nine planets and the other heavenly bodies that revolve around the sun. Ours is not the only planetary system in the universe. Astronomers have found over a billion galaxies, huge groups of stars, in the universe, and each of these is believed to contain billions of stars. A small percentage of these stars, perhaps one in a hundred or a thousand, have planets and smaller bodies that orbit around them. The word solar comes from the Latin word sol, which means sun.

2. What does our solar system include?

Our solar system includes the sun, nine planets and their satellites, moons, asteroids, meteors, and comets which revolve around the sun.

3. What holds the solar system together?

The solar system is held together by gravitational attraction.

4. Who was Ptolemy?

Ptolemy was a Greek who lived in 140 A.D. and taught what is known as the Geo-centric theory of the universe.

5. What is the Geo-centric theory?

This theory stated that the earth was the center of the universe and all things revolved around it.

6. What is the Helio-centric theory and who first advocated it?

Copernicus, a Polish astronomer, believed that the earth and other planets revolve around the sun. These ideas were set forth in his book published in 1543.

7. Name the planets in order from the sun.

The planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

8. Which of these planets have shorter years than Earth and why?

Mercury and Venus have shorter years than Earth because a year is determined by the length of time it takes for one orbit of the planet around the sun. These planets are closer to the sun, so the length of their orbits are shorter than earth's orbit, their orbital speeds greater than the earth's and hence their orbital time is shorter than earth's.

9. Do the planets have the same number of hours in their days?

No, each planet is spinning at a different rate so the rotation period of the planets differ. Chart will show the rates.

10. Which planets are considered the small planets?

Mercury and Pluto are considered the small planets.

11. What planets are the average-size planets?

Venus, Earth, and Mars are average-size planets.

12. Which are the giant planets?

Jupiter, Saturn, Neptune and Uranus are the giant planets.

13. Why does Pluto seem to be out of place in the orderly system and what is one explanation given by scientists?

Pluto is a midget in the realm of the giants and its orbit is out of shape with the orbits of the other planets. (It actually crosses into the orbit of Neptune.) Scientists believe that it may have been a moon of Neptune.

14. Using Bode's Law, how far is Saturn from the Sun?

In 1772, the German astronomer, Johann Bode, showed the distance of the planets from the Sun by using a mathematical law. To a series of numbers, each (except for the second) twice the value of the preceding one (0, 3, 6, 12, 24, 48, 96, 192) he added 4 and then divided each number by 10. These numbers, he said, represented the distances of the planets from the sun, in astronomical units. (93,000,000 miles = 1 astronomical unit). Example: the number for Venus is 3, then add 4 which gives 7, and divide by 10 which gives a distance of .7 astronomical units. If the student wants to figure this in miles, he simply multiplies .7 times 93,000,000 and he has the distance in earth miles. The measurement is not exact but in space it is usable.

When figuring Saturn's distance you must skip the number between Mars and Jupiter for this is where the asteroids belong. It was this law that helped in the discovery of these small bodies. Astronomers figured that there must be a planet there. Saturn's distance is [96 + 4] ÷ 10, or 10 astronomical units from the Sun.

15. How did Bode's Law lead to the discovery of Uranus?

Astronomers wanted to test the Law so they doubled the number assigned to Saturn and began looking for a planet in this orbit. They found Uranus in this manner.

16. What did astronomers find between Mars and Jupiter?

The asteroids or planetoids were found. (Average distance 2.4 AU's.)

17. What is the name of the largest asteroid?

Ceres, 480 miles in diameter, is the largest asteroid.

18. What is the general shape of the planets? Of the asteroids?

The general shapes of the planets are approximately spherical. The asteroids are irregular in shape. Many are oblong.

19. What is the average size of an asteroid?

Fifty miles in diameter is the average size.

20. About how many asteroids have been found?

About 2,000 asteroids have been found.

21. What could be a possible use for the asteroids?

Since they come nearer to the Earth than any other heavenly body except the Moon, they could be used as space stations.

22. How large are some of the smaller ones?

Some have been detected that are only a mile in diameter; there may be even smaller ones.

23. What are some possibilities of their origin?

They may be the remains of a planet that was broken or be parts of a ring of separate particles remaining from the original matter out of which the solar system was formed.

24. From where do planets get their light?

The planets reflect light from the Sun.

25. Which planet is the densest and also the smallest?

Mercury is the densest and the smallest planet.

26. What is the length of its period of rotation and revolution?

It is believed that Mercury rotates in fifty-seven days. It revolves in eighty-eight days.

27. What does the fact that Mercury has a low albedo tell us about its atmosphere?

There is no atmosphere because an atmosphere would reflect light. The gravitational attraction of this planet was not strong enough to hold atmosphere.

28. Why does Mercury not have any satellites?

Probably it is too small to hold a satellite in orbit or the attraction of the Sun would pull satellites into it.

29. Which planet is called the evening star?

It is Venus, because it sometimes shines very brightly in the evening.

30. Why is it so bright?

It has an atmosphere and is close to us.

31. What is Venus' distance from the Sun, using Bode's Law?

Its distance is [3 + 4] ÷ 10 = .7 astronomical units (A.U.).

32. Why can't we see the surface of Venus?

Venus has a very deep, heavy cloud covering which hides the surface.

33. What did the Mariner II find out about Venus' surface temperature?

It was 800°.

34. How is Venus similar to the Earth?

It is nearly as large as Earth.

35. Can Venus' atmosphere be helpful to Earth space travelers?

No, it contains little if any oxygen and keeps the surface temperature of Venus at an unbearable high.

36. What planet might be hospitable to Earth colonization? Give some reasons for your answers.

Mars has some oxygen in its atmosphere but not enough for Earth men to breathe. Some very low stages of plant life may exist and there may be water beneath the surface. The temperature is not as extreme as other planets and the surface is solid.

37. Compared to Earth what is Mars' size?

It is a little over one-half the size of Earth.

38. How does the weak gravitational attraction affect Mars' albedo and atmosphere?

Low albedo and little atmosphere are a result of weak gravitational attraction.

39. Why are the seasons on Mars twice as long as those on Earth?

Because Mars' period of revolution is twice as long as Earth's period of revolution.

40. What are some of the outstanding or interesting features of Mars?

Mars has: (a) questionable canals. (There is a theory about vegetation lining them.) (b) Two moons, one of which revolves every seven hours. (One can see a moonrise twice a night.) (c) Polar caps which expand and recede. (d) Terrible winds and dust storms. (e) A reddish color.

41. Which of the planets is the largest?

Jupiter is the largest of all the planets.

42. What is its general appearance as seen through a small telescope?

It is reddish with green bands and has polar caps.

43. Who was the first to see Jupiter through a telescope and what was the significance of his discoveries?

Galileo first saw Jupiter's moons and realized that the Earth was not the center of the universe if other bodies had satellites.

44. How many moons does Jupiter have? What are their sizes?

Jupiter has twelve moons, some of which are small and others are relatively large. Jupiter has a very hostile atmosphere but its moons do not, so they may some day be used by man for space stations.

45. Why is Jupiter like a star?

Because it is very large and has a dense cloud-deck from which it is capable to reflect a great deal of sunlight.

46. Fill in Jupiter's revolution and rotation periods on your chart.

47. Which planet has rings?

Saturn has three beautiful rings.

48. What are these rings made of?

These are composed chiefly of ice crystals and rocks. There is one large ring and two smaller rings.

49. What is one theory of the formation of these rings?

It is believed that once a moon of Saturn had broken apart. Its parts kept colliding and breaking into smaller pieces.

50. What is interesting to note about one of Saturn's moons?

Titan is larger than the planet Mercury and has an atmosphere.

51. Which planet spins on its side?

Uranus spins on its side.

52. Check chart for period of revolution and period of rotation of this planet.

53. Discuss why this planet would not be a suitable space station.

54. How was Uranus discovered?

Uranus was discovered through the use of Bode's Law.

55. What fact led to the discovery of Neptune?

Uranus' orbit was being pulled out of shape. The cause proved to be a planet, Neptune.

56. What do some scientists think about the origin of Pluto and why?

Scientists believe that it was once a moon of Neptune because it is so small, and its orbit is irregular.

57. What is the general shape of the orbits of the planets?

The general shape of their orbits is elliptical.

58. What are the parts of a comet and of what are they made?

A comet is composed of a large mass of frozen gases embedded with chunks of metal, and a tail, which is composed of gases.

59. In what direction does the tail always point?

The tail points away from the sun because of the pressure from solar radiation.

60. What are the two groups into which comets are classified? Explain.

There is the periodic group which return every so many years, and the non-periodic group which either do not return or have periods so long that they have never been seen twice in recorded history.

61. What is the name of one of the most famous comets and in what year will it return to the Earth?

Halley's comet is one of the most famous and spectacular. It will return in 1986.

The Stars

1. What is the general shape of stars and why do they seem so small?

They are round and are very far away.

2. What is the name of the nearest star and how close is it to us?

The nearest star to us other than our sun is Alpha Centauri and Proxima Centauri. It is a double star and about four light years away.

3. What is the definition of a light year?

It is the distance light travels in one year.

4. How fast does light travel?

Light travels approximately 186,000 miles per second.

5. Write this as an equation.

186,000 x 60 x 60 x 24 x 365¼ = 1 light year.

6. Upon what does the brightness of a star depend?

Size, relative radiation, and distance from us all affect the apparent brightness of a star.

7. What does the color of a star tell us?

The color of a star tells us its age and its temperature.

8. What colors indicate the hottest stars, the medium, and the coolest?

The hottest stars are white and blue.
The medium stars are yellow like our sun.
The coolest stars are red.

9. Why do the stars seem to move through the heavens?

   The stars seem to move because of the earth's rotation and revolution.

10. What happens to the stars during the day?

    They are still there but our sun's light is so bright that it hides the stars from our vision. From a deep well or through a chimney one can see the stars in the daytime.

11. What is the source of light of the stars?

    The light of stars is due to their own radiation.

12. What is a constellation?

    A constellation is the grouping of certain stars on the celestial sphere. The ancients recognized the groups as human and animal figures and even some inanimate objects.

13. Name three well-known constellations.

    Orion, Ursa Minor and Ursa Major are three well-known constellations.

14. What is the name of the North Star and what constellation is it in?

    The North Star is Polaris. It is in the Ursa Minor (Little Dipper) constellation.

15. What are white dwarfs?

    They are tiny stars about 1,100 miles in diameter. Each cubic inch may contain several tons of matter.

16. What are the two ways in which a star can die?

    They may simply burn out slowly, in which case they become white dwarfs or they may explode as a nova.

17. What is a pulsating star?

    A pulsating star is one that swells up and then shrinks, becoming bright and then dim, over and over again like heavily breathing monsters. The really large pulsating stars may take as long as two or three years to complete one cycle of swelling and shrinking, but the smaller ones are quicker. They take only a few days, or even hours, to expand and contract.

18. What is a nova?

    It is a star that suddenly explodes and becomes brighter and brighter until it rules the heavens. It may remain bright for several years, then it will slowly grow dim, returning to its normal stage, after having cast off a great deal of its matter.

19. What is a supernova?

    A supernova is a star which simply blows itself to smithereens. Examples: Crab Nebula; Kepler's Nova in Ophiuchus; Tycho Brahe's nova in Cassiopeia.

20. What is a double star?

9. Why do the stars seem to move through the heavens?

The stars seem to move because of the earth's rotation and revolution.

10. What happens to the stars during the day?

They are still there but our sun's light is so bright that it hides the stars from our vision. From a deep well or through a chimney one can see the stars in the daytime.

11. What is the source of light of the stars?

The light of stars is due to their own radiation.

12. What is a constellation?

A constellation is the grouping of certain stars on the celestial sphere. The ancients recognized the groups as human and animal figures and even some inanimate objects.

13. Name three well-known constellations.

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20. What is a double star?

When two stars are situated close together and circle about each other they are called a double star.

21. What is an optical double star?

    An optical double star are two stars which lie nearly in the line of sight as seen from earth, thus giving the appearance of a double star in the sky.

22. Is our North Star a double star?

    No, it is made up of three stars.

23. Choose one star and give some interesting facts about "your star."

The Moon

1. What is a moon?

   A moon is a satellite or body revolving about a planet or other body.

2. What is the Latin name for the earth's moon?

   Its Latin name is Luna.

3. Approximately how far away from the earth is the moon?

   It is approximately 240,000 miles from the earth.

4. How large is the moon compared to the earth?

   It is approximately one-fourth the size of the earth.

5. Why would you weigh less on the moon?

   Because the moon has less mass than the earth, the gravitation law.

6. What is meant by the terms apogee and perigree of the moon?

   Apogee is the point of the moon's orbit around the earth that is farthest from the earth and the perigree is the point of the moon's orbit closest to the earth.

7. (a) What is the sidereal period of the moon?

   The sidereal period is the time it takes the moon to make a complete circuit around the earth from one star back to the star again, as seen from the sun, not the earth. This is about twenty-seven and one-third days.

   (b) What is the synodic period of the moon?

   The synodic period is the interval between successive similar phases of the moon, full to full or new to new. This is about twenty-nine and one-half days.

8. Why do we see only one side of the moon?

   Because the moon rotates once upon its own axis in the same time as it completes one revolution around the earth.

9. What is on the other side of the moon?

   The moon is the same on all its surfaces. This has recently been demonstrated by photographs.

10. What are two theories of the origin of the moon's surface features?

It is thought that the moon's surface features were caused from either volcanic eruption or meteor collision.

11. What are three theories of the origin of the moon?

The moon might have been pulled from the earth. (The Pacific Ocean is now left as a result of this fact.)
It might have been formed by contraction of gases.
It might have been formed by an attraction of bodies to become a mass.

12. What are the extremes of the moon's temperature? Give the cause of these extremes.

The extremes are approximately 100°C. directly below the sun and -150°C. during the long lunar nights.

The reason for these extremes are that because there is no protective atmosphere the moon's surface becomes hot enough to boil water and also since there is no atmosphere to trap the heat-producing infra-red rays of the sun, radiation into space goes on unhindered and temperatures drop many degrees below freezing.

13. What is meant by escape velocity and what is the earth's and moon's escape velocity?

It is the speed that an object must obtain to overcome the gravitational attraction of another body. An object on earth must pull away form earth at seven and one-half miles per second. How much is that per hour? An object to pull away from the moon's gravitational attraction must pull at one and one-half miles per second. The class might discuss here why the launching of a spacecraft from the moon has fewer problems than a launch from earth.

14. What is meant by the term albedo?

Albedo refers to the amount of light reflected by an object. If it has a high albedo then the object is reflecting a large amount of light and must be composed of a surface of highly reflective material or be surrounded by an atmosphere which is reflective.

15. What is the line between darkness and light on the moon called?

This line is called the terminator.

16. What does this line tell us about the atmosphere of a body? Explain.

If the line is fuzzy indicating a zone of twilight then the body has an atmosphere. If the line is sharp, like that on the moon, then the body has no surrounding atmosphere.

17. What does the general surface of the moon look like?

The surface is composed of small crumbly rocks. Until just recently it was thought that the surface might be fine dust, perhaps miles deep.

18. How do scientists explain this type of surface?

They say that the extremes of heat and cold cause cracking of rocks.

19. What are the surface features of the moon and describe each?

    Craters--large round depressions
    Rays--long indented lines radiating from the craters
    Rills--long deep depressions on the moon's surface
    Mountains--often as high and sometimes higher than earth's and usually found surrounding the craters
    Maria or seas--large plains once thought to be seas

20. What causes the face on the moon?

    The maria are composed of a darker material than the surrounding area. These dark areas resemble a face to the observer.

21. What does the moon have to do with the tides on earth?

    Its mass exerts a pull on the earth and both land and water are pulled toward the moon. Since water is pulled more easily, it is very noticeable as tides.

22. What law explains this and why doesn't the sun, because of its size, have more influence on the tides than the moon?

    It is explained by the law of gravitation. The sun is so far away it does not influence the tides as much as the closer moon.

23. Draw and label the phases of the moon in one month.

24. What did Project Surveyor accomplish?

    Project Surveyor made a soft landing on the moon.

25. What is the difference between a hard and soft landing on the moon?

    In a hard landing, the space ship crashes on surface and is damaged and destroyed.
    In a soft landing the space ship comes down gently and is of value after set down.

26. What are some of the reasons why we want to get to the moon?

    We want to get to the moon:
    (a) for scientific reasons
    (b) to establish space stations for further explorations of space
    (c) the moon will make an excellent observatory
    (d) for military reasons

27. What causes an eclipse of the moon?

    An eclipse of the moon occurs when the moon happens to enter into the earth's shadow.

28. If you were on the moon, what would be some of the things that would seem strange to you?

    The class might trace their typical day here and decide what things would have to be different in their lives if they lived on the moon. Examples: they could not raise money by cutting grass because grass would not grow or they could not fly a kite because there is no air in which to fly it.

29. What is Project Apollo?

Project Apollo is a U.S. space program to attempt to successfully put man on the moon.

30. When is the estimated time for this to happen?

The year 1968 is the estimated date.

31. Name the projects that preceded Project Apollo and describe their principal achievements.

Mercury was a one-man spacecraft that orbited the earth. Students can fill in other information from their reports. Gemini was a two-man spacecraft that orbited the earth. Students may give further information here from their reports.

Our Galaxy and the Universe

1. Define the term universe.

The universe is all that is contained in the vast expanse of space around us.

2. What space objects are closest to Earth?

Our moon, neighboring planets, and the asteroids are the space objects closest to Earth.

3. What is the Milky Way and what does it contain?

It is the galaxy of which we are a part. It is made up of billions of stars. Our sun and the whole solar system is on one of the spiral arms of this galaxy and is about 27,000 light years from the center. It is a spiral-shaped galaxy.

4. What is the nearest spiral galaxy to us and how far away is it?

Andromeda is approximately 1,500,000 light years away from Earth.

5. What will we find in space and what is this called?

Nothing is found and it is called outer space.

6. What is the color of space and why?

Space is black because there is no atmosphere to refract the light.

7. What is the basic difference between the two theories for the origin of the universe?

One theory states that the universe is in a steady state of being with the old dying and the new forming. The other theory states that everything has already been made and is being used up and expanding outward.

8. Draw the shape of the Milky Way.

9. Draw the shapes of two other galaxies.

10. What is the value of radio telescopes?

They can pierce through our atmosphere where telescopes cannot penetrate and therefore probe further into space.

11. What is Project Ozma?

    A group is sending out radio blips in the direction of signals that were picked up from space. They hope to get a reply.

12. What is the name of the group of galaxies of which the Milky Way is a part?

    It is called the Local Group.

13. Are the galaxies moving apart?

    Yes, everything in the universe is moving away from a center point.

14. Why can't we see the thick cluster of stars in the center of the Milky Way?

    Between us and the bright center are many dark clouds of interstellar dust and gases which are hiding what is probably the most exciting view in the entire galaxy.

15. What reasons do the scientists give for our galaxy being in the shape of a disc?

    They say that the Milky Way is forever spinning like a giant Fourth of July pinwheel, but its spin is much slower than that of a pinwheel. Astronomers say that in the last two billion years or so, our galaxy has made fewer than ten complete turns. But, in spite of its slow motion, the stars on the rim of the galaxy are thought to be whipped around at hundreds of miles a second. Astronomers think that the pinwheel motion is what has caused our galaxy to flatten out into the disc shape.

16. What are nebulae?

    Vast clouds of gas and dust swimming endlessly in the black ocean of outer space are called nebulae.

17. If you could examine the cup section of the Big Dipper, how many galaxies would you find?

    About 300 galaxies would be found in the cup section of the Big Dipper.

Space Travel and Explorations of Today and the Future

1. What are some of the problems facing our space men today?

   Perhaps students could report on the various problems in medicine, biological and technical problems, time involved, and dangers of space travel.

2. Is there much chance of spacemen being hit by meteors?

   No, because there is too much space.

3. What was the name of the first man-made satellite and the first satellite to carry a passenger?

   The Russian satellite Sputnik carried a dog named Leika.

4. What was the name of the first United States satellite and when was it launched?

   Explorer I, launched January 31, 1958, discovered the Van Allen radiation belts.

5. What are the four different types of jobs done by satellites?

   Jobs done by satellites are the following: navigation, communication, military, and scientific.

6. What are the four kinds of space probes?

   (a) Sounding rockets carry instruments into the upper atmosphere and into space near earth. They soar to heights of fifty to 4,000 miles above the earth and then fall back.
   (b) Lunar spacecraft will explore the moon to prepare the way for man to land there. Surveyor was a United States lunar space probe.
   (c) Interplanetary probes go on one-way journeys into interplanetary space. These probes do not reach planets.
   (d) Planetary probes are sent mainly to the nearby planets Venus and Mars. These probes travel in orbits around the sun. They generally do not strike the target planet. Instead, they fly by at distances of several thousand miles.

7. How are satellites put into space?

   They are lifted off by huge rockets. Students may report on various rockets.

8. Why do we launch satellites near the equator and fire them into the east?

   By doing so we make use of the spin of the earth.

9. What was the International Geophysical Year?

   The year 1957-1958 in which scientists all over the world cooperated in studying the earth and its environment in space was called the International Geophysical Year.

10. Who is Werner von Braun?

    He is the scientist known as our Father of the Space Age.

11. What are some of the outstanding rockets developed by the United States?

    Mercury-Redstone, Atlas-Agena, Titan II, and Saturn V are a few of our rockets.

12. What is a space station?

    A permanent satellite to be used for a space base is called a space station.

13. What is one way that scientists think they can simulate the force of gravity in a space station?

    By making the space station rotate like a giant gyroscope.

14. What would be some of the uses for a space station?

    They could be used for observation, launching of space explorations, military purposes, and scientific research.

15. What is astronautics?

The science that deals with problems of space travel is called astronautics.

16. Choose a space flight or exploration and give interesting details about it.

17. Who are some of the United States astronauts?

A few are Sheppard, Carpenter, White, and Glenn.

18. What is a cosmonaut?

A Russian astronaut is called a cosmonaut.

19. Where are most of our space rockets launched?

They are launched at Cape Kennedy, Florida.

20. What is the name of the rocket that will take man to the moon and tell something of its size?

Saturn V is almost as large as the State Capitol Building.

21. Briefly tell the flight plan of man's trip to the moon.

Three men will leave Earth and go into orbit around the moon. One man will man the large command ship orbiting the moon while the other two men will travel in the small service module section to the moon. After exploring, the two will return in the smaller ship and join the command ship. The three men will immediately return to Earth.

22. Why will they not need much rocket power to leave the surface of the moon?

There is not as great a gravitational force on the moon.

23. Who was the first United States astronaut to take a space walk?

Edward H. White, II, took the first space walk.

24. What is meant by the term docking?

The joining of one spacecraft with another in space is called docking.

TEST--This covers items from all the worksheets.

I. Completion - Place the correct word in the blank to the left of the statement.

1. Our solar system is part of a galaxy known as the ______________. [Milky Way]

2. The last stage of the United States space program designed to put man on the moon is called ____.[Apollo]

3. Three rockets developed for United States space explorations are ____, ____, and ____. [Agena, Redstone, and Explorer]

4. The famous German scientist who helped in the United States space program is ____. [Von Braun]

5. The inventor of the telescope was __________. [Galileo]

6. The theory that the earth revolves around the sun is known as the _____ theory. [Heliocentric]

7. The point in the orbit of a satellite that is closest to the earth is the _____. [Perigee]

8. The _____ on the moon give the moon a "face." [Maria or seas]

9. The _____ is the line between darkness and light on the moon. [Terminator]

10. Time and seasons on the earth are both relative to the earth's position to the _____. [Sun]

11. The distance from the earth to the sun is _________. [93,000,000 miles]

12. The two planets most similar to Earth are _______ and _____. [Venus and Mars]

13. The planet which scientists have the greatest hope for finding life is _____. [Mars]

II. Matching - Place next to the numbers the letter from the word list that best fits the statements below.

a. Law of gravitation
b. Rotation
c. Revolution
d. Atmosphere
e. Lack of atmosphere
f. Law of gases
g. Retrogation
h. Magnetic fields

b 1. Speed of which determines length of day.
a 2. The moon's escape velocity is less than the earth's.
a 3. Keeps the moon and the planets from shooting off into outer space.
c 4. Reason for your age being twelve-years old.
a 5. Causes the tides to rise on Earth.
d 6. Reason for Earth's blue skies.
e 7. Reason why the moon would be a good place for a telescope.
d 8. Causes the stars to twinkle.
b 9. Causes the equatorial bulge on Earth and on some of the other planets.
a 10. Reason why you could jump very high on the moon.
e 11. Reason why there are extremes in temperature on the moon.
e 12. Reason why there is no "twilight zone" on the moon.

c 13. Reason why a year on Saturn is longer than the year on Mars.

d 14. Reason why it is so hot and dark on the surface of Venus.

d 15. Reason why meteors glow.

a,e 16. Reason why Mercury has a low albedo.

d 17. Reason for the heat shield on the space capsules.

e 18. Reason why our astronauts need clothing of special material to protect them from the sun.

III. Choose the best item from Column B which matches the statements in Column A.

	Column A	Column B
a,h	1. constellation	a. Andromeda
a	2. spiral galaxy	b. Neptune
l	3. nearest star to Earth	c. Polaris
k	4. red planet	d. Betelgeuse
g	5. evening star	e. Ceres
i	6. largest of planets	f. Sputnik
c	7. North Star	g. Venus
e	8. asteroid	h. Ursa Major
f	9. man-made satellite	i. Jupiter
m	10. instrument on the moon	j. Saturn
		k. Mars
j	11. rocket for moon flight	l. Alpha Centauri
n	12. Earth's moon	m. Surveyor
		n. Luna

IV. Multiple Choice - Select the answer that best completes the statement and makes it true. Place the letter in the blank to the left of the number.

b 1. A meteorite is a
(a) small asteroid
(b) a piece of meteor that hits the earth's surface.
(c) a satellite
(d) a meteor that burns up as it hits the atmosphere.

a 2. Blue-white stars are
(a) new and very hot
(b) young and cool
(c) old and cool
(d) old and very hot.

d 3. Stars seem to move across the sky because
(a) they are in orbit
(b) the clouds are moving
(c) of centrifugal force
(d) the earth is moving
(e) all of the above are correct.

d 4. The apparent brightness of a star depends upon
(a) its size
(b) how hot it is
(c) its distance from Earth
(d) all the answers are correct.

a 5. We fire satellites near the equator and usually into the east because
(a) of the earth's rotation
(b) of the earth's revolution
(c) of the wind direction
(d) of the equatorial bulge.

_b_ 6. Space is very vast and is filled with countless objects but the main thing that is found in space is
(a) galaxies
(b) empty space
(c) stars
(d) sunlight.

_c_ 7. The sun puts out a tremendous amount of light and heat and
(a) most of it reaches earth
(b) most of it is blocked out by the earth's atmosphere
(c) most of it goes into space
(d) most of it is reflected by the moon.

Student Activities

The Earth

1. Demonstrate to the class ways which help us prove that the earth is spherical.
2. Demonstrate to the class the cause of day and night.
3. Show the class the cause of winter in the North Frigid Zone and South Frigid Zone.
4. Demonstrate how a Foucault Pendulum works.
5. Demonstrate how an object spins on its axis.
6. Demonstrate the parallax method for proving the movement of the earth.
7. Demonstrate the cause of the equatorial bulge.
8. Make a diagram of the three main layers of the earth and the main layers of the atmosphere. Label what is found in each and report to the class.
9. Make a drawing of the United States showing the standard time zones.
10. Make and display in the classroom time exhibits showing the time at one given point at various places in the world.
11. Make and display models of various time telling devices such as the water clock, measuring candle, and hour glass.
12. Demonstrate how the albedo of a planet tells us something about it.
13. Find out about the aurora borealis and report to the class.

The Moon

1. Keep a chart of the moon's phases for four weeks, displayed for the class to see every day.
2. Model the moon from clay including all the general features and label.
3. Report with drawings showing theories of the moon's origin and the origin of the various surface features.
4. Describe to the class a baseball game played on the moon. (Football, tennis, may be substituted.)
5. Read some of the legends connected with the moon and tell the class your favorite. (This may be done by more than one student.)
6. Write your own legend of the moon.
7. Build your own Apollo spacecraft and using it for a model explain to the class how man will get to the moon and back.
8. Give a report of what Project Surveyor found out on the moon.
9. Give a report on how the moon has been used in music, art, and literature.

10. Find out what you can about the moons of other planets. Tell the class about the interesting facts that you have discovered.

The Sun and the Solar System

1. Find and bring in examples of how the sun has been used in art.
2. Find and bring in examples of how the sun has been used in religion.
3. Find out what is happening in the different parts of the sun.
4. Describe a day in your life without the heat and light from the sun.
5. Describe the planet Earth after a month of no sun.
6. Give a report on the Greek origin of the various names of the planets.
7. Make a poster chart of all the planets and tell the class some interesting facts about each.
8. Figure out how old you would be if you lived on each of the planets. Put this on a chart for the class to see.
9. Read about some of the more famous meteorites that have hit the earth and tell the class about them.
10. Report on the discovery of Neptune by Leverrier in France and J. C. Adams in England. (If you use the book Exploring the Planets by Roy Gallant you will find the reading fascinating.)
11. Report on the discovery of Pluto by Percival Lowell and his associates in the United States. (Read No. 10 for source.)
12. Report on the discovery of Uranus by William Herschel working in England. (Read No. 10 for source.)
13. Make a diagram of the solar system showing the planets in their orbits.
14. Explain to the class using diagrams, what happens in atomic fission and atomic fusion.
15. Give a demonstration showing the class the concept of inertia.
16. Solve these mathematical problems.
    (a) How long would it take a rocket to travel from the earth to the sun if its average speed were 25,000 miles per hour?

    (b) Light travels about 186,000 miles per second. How many minutes does the light from the sun take to reach the earth?

    (c) Uranus was discovered in 1781. How many complete revolutions has it made since then? How many has the earth made?
17. Make a chart showing the cause of the light of a planet, comet, meteor, sun, and the moon.

The Universe, General Astronomy, and Space Explorations

1. Make a chart and give a report on the color of the stars.
2. Make a chart showing the different kinds of objects found in the universe. Start at the smallest unit and work toward the larger.
3. Explain the big squeeze and big bang theory of the origin of the universe to the class.
4. Explain the steady state theory of the universe to the class.
5. Demonstrate to the class how the universe is expanding.
6. Give a report on what was accomplished by Project Mercury.
7. Read the mythological story of Mercury and explain why this name was given to our first space project.
8. Report on the Gemini project and what was accomplished.
9. Read the mythological story of the Gemini and tell why it was picked for the name of our second space program.
10. Give a report on the mythological story of Apollo and explain to the class why this name was given to our next space project.
11. Report on these men in the light of what they contributed to space:

    (a) Galileo
    (b) Copernicus
    (c) Johann Kepler
    (d) Isaac Newton
    (e) Tycho Brahe

12. Report on the famous telescopes in the United States.
13. Report on what it is like to be an astronomer and what kind of person should you be to have this type of career.
14. Be responsible for a bulletin board on which will be posted any news about the sky or explorations into space.
15. Read some of the current science fiction short stories and tell your class what was believable and what was not in the stories. Also tell where the author used scientific knowledge.
16. Write your own science fiction story trying to base as much as possible on fact.
17. Write the news story of man's first trip to Mars. You have just interviewed the commander of this space ship.
18. Design a Martian house that man will have to build in order to live there.
19. "Man can explore space in four stages." This quotation is taken from the 1966 Year Book of World Book Encyclopedia. Have a four-man panel to discuss each of these stages. (Page 151.)

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Baker, Robert H. *Introducing the Constellations*. Viking, 1957. Illustrated. Pp. 209.
Information and legends about constellations and a section containing excellent photographs. (A)

Baker, Robert H. *When Stars Come Out*. Revised edition. Viking, 1954. Illustrated. Pp. 182.
A brief history of astronomy along with modern astronomical facts. Describes the role of modern telescopes in astronomy. (I)

Bendick, Jeanne. *The First Book of Space Travel*. Franklin Watts, Inc., 1953. Illustrated. Pp. 69.
About space and the principles of rockets and space travel. Also about what clothing will be worn during a space trip, how a space platform will be made, and where in space man will travel. Contains an introduction to the planets and possible life on them. (P)

Binder, Otto. *Planets*. Golden Press, 1959. Illustrated. Pp. 56.
A guide to the bodies of our own solar system. (I)

Binder, Otto. *The Moon*. Golden Press, 1959.
Origin, rotation, topography, and mysteries of the moon in color. (I)

Bonner, Mary Graham. *Wonders Around the Sun*. Lantern, 1957. Illustrated. Pp. 118.
An interesting view of the solar system. (I)

Branley, Franklyn M. *A Book of Satellites For You*. Thomas Y. Crowell Co., 1959. Illustrated. Pp. 48.
This book for very young readers describes the satellites that have already been launched and those that will be sent up in the future. Why man sends up satellites, what he hopes to learn from the messages they send back to earth, and how these messages are sent. (P)

Branley, Franklyn M. *Experiments in Sky Watching*. Crowell, 1959. Illustrated. Pp. 111.
The young sky watcher is given an introduction to orderly observation of the heavens and to experiments that will be of great interest. (A)

Branley, Franklyn M. *Mars*. Crowell, 1955. Illustrated. Pp. 148.
Everything the amateur astronomer would like to know about this planet is given here in an uncomplicated manner. (A)

Branley, Franklyn M. *The Moon*. Crowell, 1960. Illustrated. Pp. 114.
A full presentation of our knowledge about the moon. (A)

Branley, Franklyn M. The Nine Planets. Crowell, 1958. Illustrated. Pp. 77.

Detailed descriptions of the planets; their distance from the sun, temperature, size, rotation period, mass, density, and physical composition. (I)

Crosby, Phoebe. Junior Science Book of Stars. Garrard, 1960. Illustrated. Pp. 64.

Day and night, the seasons, and the phases of the moon are explained in easy language. Gives some basic facts about the planets and the stars, and tells how to find and recognize several important constellations. (P)

Drake, Frank D. Intelligent Life in Space. Macmillan, 1962. Illustrated. Pp. 128.

The possibility of life other than that on earth is thoroughly explored. Shows how planets may be formed, how life may develop, and how we might locate other civilizations. (A)

Fenton, Carroll Lane, and Mildred Adams Fenton. Worlds in the Sky. Day, 1963. Illustrated. Pp. 96.

A factual account of the seasons, eclipses, the earth's rotation and related phenomena. Covers considerable territory dealing with the earth, the solar system, the stars, and the universe in general. (I)

Freeman, Mae and Ira. Fun With Astronomy. Random, 1953. Illustrated. Pp. 57.

Accompanied by suggested experiments, instructive projects, and useful illustration, the text reveals some important aspects of the sun, planets, comets, and stars. (I)

Freeman, Mae and Ira. The Sun, The Moon, and The Stars. Random, 1959.

Short, simple experiments and effective, easy-to-read explanations make this a good introduction to the heavens for the child with no previous experience in astronomy. (I)

Gallant, Roy A. Exploring the Planets. Garden City, 1958. Illustrated. Pp. 56.

Detailed description of each planet is presented, with the aid of many excellent illustrations, tables, and diagrams.

Gallant, Roy A. Exploring the Sun. Garden City, 1958. Illustrated. Pp. 56.

This is an account of the evolution of man's ideas about the sun from his earliest superstitions to his modern theories. The birth and death of the sun, sunspots, prominences, and flares are among the topics covered. (I)

Gallant, Roy A. Exploring the Universe. Garden City, 1956. Illustrated. Pp. 62.

Traces the growth of astronomy from the ancient Chinese to the present time. Then explores topics such as the types of stars, novae, meteors, comets and the expanding universe. Outstanding drawings complement the brief text. (I)

Gamow, George. The Moon. Abelard, 1957.

Recent data about the earth's satellite; its origin, orbit, gravity, surface features, effect on tides, eclipses. (I)

Guillot, Rene. Astronomy. Whitman World Library. Whitman

Branley, Franklyn M. The Nine Planets. Crowell, 1958. Illustrated. Pp. 77.

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Recent data about the earth's satellite; its origin, orbit, gravity, surface features, effect on tides, eclipses. (I)

Guillot, Rene. Astronomy. Whitman World Library. Whitman Publishing Co., 1965.

An excellent book covering all phases of astronomy. Very well illustrated with easy to understand text. (I)

Haber, Heinz. *Stars, Men and Atoms*. Golden, 1962. Illustrated. Pp. 188.
This 1962 Edison Foundation Award winner recounts the story of man's conception of the universe from Aristotle to Einstein. Theories of the nature of the universe and modern exploration of space are described, and research on man-made satellites and life on other planets is lucidly reviewed. Helpful photographs and drawings. (A)

Kinney, William. *Medical Science and Space Travel*. Watts, 1959.
Helping man to survive the harmful aspects of space travel. (I)

Lauber, Patricia. *All About the Planets*. Random, 1960. Illustrated. Pp. 139.
Gives detailed and interesting descriptions of each planet and tells exactly what we know and do not know about the bodies of our solar system. (I)

Lum, Peter. *The Stars in our Heaven*. (Myths and Fables.) Pantheon Books, Inc., New York, 1948.
Tells of the many myths which have come down through the ages about the constellations. (I)

May, Julian. *Astronomy*. Pennington, 1959.
The earth in space; the astronomer's tools and discoveries; the planetarium; the sky maps. (I)

May, Julian. *Space Travel*. Pennington, 1959.
The world of spacemen, missile engineers and moon rockets; colorful diagrams; glossary of terms. (I)

Neely, Henry M. *The Stars by Clock and Fist*. Viking, 1956.
Clear, simple method; sky maps, time charts, diagrams; excellent. (I)

Pickering, James. *The Stars Are Yours*. Macmillan, 1953.
Primarily centered upon the stars that can be seen without a telescope. (I)

Polgreen, John and Cathy. *A Look at the Moon*. Doubleday & Co. 1962.
A beginning scientist's book which gives satisfactory answers to questions most often asked about the moon. Illustrated by the authors. (I)

Reed, W. Maxwell. *Patterns in the Sky*. Morrow, 1951.
Detailed charts of the twenty-five most familiar constellations and their legends. Excellent. (I)

Schloat, G. Warren. *Andy's Wonderful Telescope*. Scribner's, 1958.
Photographs show how the telescope was developed and the principles of reflecting and refracting telescopes; simple text. (I)

Wyler, Rose and Gerald Ames. *The Golden Book of Astronomy*. Simon, 1955.
Complete, well-illustrated summary; charts of the constellations and a moon map. (I)

Zim, Herbert. *Comets*. Morrow, 1957.
Simply written for the older child who had reading problems; very complete. (I)

Zim, Herbert and Robert Baker. *Stars: A Guide to the Constellations, Sun, Moon, and the Planets*. Simon, 1956.
A pocket guide, complete and very usable. (I)

Suggested Textbooks

Beauchamp, Blough, Marshall, Bailey. Science is Discovering. Book 5. Teachers Edition. Scott, Foresman and Co., 1964.

Craig, Gerald, and Katherine Hill. Science for You. Book 5. Teachers Edition. Ginn and Company, 1965.

Donald A. Hall. Elements of Astronomy and Physical Geography. Published by Trippensee Planetarium Company, Inc., Saginaw, Michigan, 1963.

Jacobson, Lauby, Konicek. Investigating in Science. Teachers Edition. Book 6. American Book Co., New York, 1965.

MacCracken, Decker, Read, Yarian. Basic Earth Science. Teachers Edition. The L. W. Singer Company, Syracuse-Chicago, 1964.

Schneider, Herman and Nina. Science in Your Life. Book 4. D. C. Heath and Company, Boston, 1961.

16 mm Films in Astronomy - Materials Bureau

Grading: P: K - 2 M: 3 - 5 U: 4 - 7 J: 7 - 9 H: 9 - 12

Beyond Our Solar System	389	MJU
Big Sun and Our Earth, The	291	PM
Earth in Motion	100	JH
Earth Satellites, Explorers of Outer Space	436	MUJHC
Exploring by Satellite	543	UJH
Exploring the Night Sky	387	MUJ
Exploring the Universe	101	JH
First Men Into Space	583	MUJ
How Many Stars	362	JH
How We Explore Space	388	JH
How We Know the Earth Moves	456	UJ
Man and the Moon	439	JH
Moon	84	JH
Moon and How It Affects Us	392	MUJ
Our Earth	12	JH
Solar Family	32	JH
Sun and How It Affects Us, The	289	MUJ
Sun's Family	194	MUJ
Trip to the Moon, A	384	MUJH
Universe	668	JH
What Causes Seasons	198	MU
What Do We See In The Sky?	288	PMU
What Makes Night and Day	159	MUJ

35 mm Filmstrips in Astronomy - Materials Bureau

Astronomy Through the Ages	2994	MU
Changing Moon, The	1598, 761	MUJ
Comets and Meteors	2289	JH
Constellations	2290	JH
Earth in Space	2291	JH
Earth's Nearest Neighbor	2152	MUJ
Earth's Satellite - The Moon	2292	JH
How We Learn About the Sky	1599	MUJ
Interesting Things About the Planets	1595, 762	MUJ
Looking at the Stars	1765	MUJ
[illegible]	2995	MUJ

Suggested Textbooks

Beauchamp, Blough, Marshall, Bailey. Science is Discovering. Book 5. Teachers Edition. Scott, Foresman and Co., 1964.

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Schneider, Herman and Nina. Science in Your Life. Book 4. D. C. Heath and Company, Boston, 1961.

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Sun's Family	194	MUJ
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What Makes Night and Day	159	MUJ

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Constellations	2290	JH
Earth in Space	2291	JH
Earth's Nearest Neighbor	2152	MUJ
Earth's Satellite - The Moon	2292	JH
How We Learn About the Sky	1599	MUJ
Interesting Things About the Planets	1595, 762	MUJ
Looking at the Stars	1765	MUJ
The Moon	2995	MUJ
A Multitude of Suns	1593	MUJ
Night Sky, The	2537	PM
Our Earth in Motion	1600	UJH
Our Neighbor, The Moon	1597, 760	MUJ
Pictures in the Sky	2153	MUJ

Sky Above Our Earth, The	2327	PM
Solar System, The	2999	MUJ
Stars, The	2997	MU
Stars and Galaxies	2293	JH
Stories of the Constellations	1594, 1925, 764	MU
Sun, The	2993	MU
Sun and Its Family, The	2154	MUJ
Sun and Its Planets	2294	JH
Sun and Our Seasons	1601	UJH
Sun's Family, The	1596, 763	MUJ
Why Do We Have Day and Night?	1943	PM
Work of Astronomers and Space Travel	2295	JH
You and the Universe	2155	MUJ
Solar System and the Universe	1331	MUJ
Stars of the Summer Night	571	MUJH

Vocabulary

The following words are just a few of the many terms which might be used in a unit on the universe to extend the children's understanding of some of the basic concepts.

1. Albedo. The reflecting power of a body which refers to the ratio of the light reflected by the whole illuminated hemisphere to the light it receives from the sun.

2. Alpha Centauri. The star that is closest to our own sun. It is a triple star.

3. Antarctic. The region around the south pole to approximately 66½° South.

4. Apogee. The point in the orbit of an earth satellite at the greatest distance from the center of the earth.

5. Apollo. The name of the American space program that involves putting three men into orbit and hopes to culminate with a man on the moon.

6. Aposelenium. The point of a lunar satellite's orbit furtherest from the center of the moon.

7. Arctic. The region around the north pole to approximately 66½° North.

8. Asteroids. These are bodies of hard material which orbit the sun. They are usually a mile or more in diameter, but some are as small as two feet in diameter. Most asteroids are found between Mars and Jupiter.

9. Astrology. The superstitious science of the stars; the belief that the motions of the planet through the stars influence our daily lives.

10. Astronomy. The study of space and all it contains.

11. Axis. A line through the center of an object about which that object rotates.

12. Comet. Small or large mass of loosely packed bits of rock and metal surrounded by a gaseous envelope that orbits the sun in an elongated ellipse; usually characterized by a tail that extends from the central mass and flows away from the sun; the tail is present only when the comet approaches the sun.

13. Constellation. A group of stars that appear to form a definite pattern in the sky, the association of the stars in a constellation is an apparent one and the constellation only appears to have its shape from our vantage point in space. If we could leave the solar system, the constellations would appear to change their shapes.

14. Copernicus. A Polish astronomer who first taught that the sun was the center of the universe.

15. Crater. A bowl-shaped depression around the orifice of a volcano; a depression formed by the impact of a meteorite.

16. Eclipse. A time when either the shadow of one heavenly body or the heavenly body itself partly or totally covers another.

17. Ecliptic. The path that the sun appears to trace through the sky in one year; in reality it is the path of the earth's orbit.

18. Ellipse. A "flattened" oval.

19. Equator. A great circle that is everywhere equally distant from the two poles and divides the earth's surface into the northern and southern hemispheres.

20. Escape velocity. The speed an object must attain to overcome the gravitational pull of a planet, or other celestial body, and escape into space.

21. Galaxy. A conglomeration, or stellar island, consisting of billions of stars and interstellar gas and dust in space, isolated from other such groups.

22. Gemini. The name of the American space program that put two men into orbit and had included in its objectives many tests that were to make possible the Apollo program. Also the constellation of the twins with two main stars, Castor and Pollux.

23. Geocentric. Earth centered.

24. Gravity. The force that holds bodies to the earth; the force of attraction between two masses of material.

25. Horizon. That point where the sky and earth apparently meet.

26. Hydrogen. The lightest and simplest of all the elements.

27. Inertia. The property of a body that resists a change in the direction or speed of movement of that body.

28. Light year. The distance light travels in one year, approximately six trillion miles, light travels at a speed of 186,282 miles per second.

29. Magnitude (Apparent). The scale of brightness of a star. The smaller the numerical value of magnitude the brighter the star; the greater the numerical value, the fainter the star. There are negative magnitudes for the very bright star.

30. Mare. Latin name for sea. Usually refers to the flat plains on the moon. Maria is plural for mare.

31. Mercury. The name of the American space program that put one man into orbit around the earth. Also the first planet from the sun.

32. Meteor. A rock-like object that travels at a high rate of speed throughout the universe. A bright streak in our sky is caused by a meteor that enters the earth's atmosphere and burns, due to friction, as it falls to earth. If a meteor fails to burn completely and strikes the earth, the remains are called meteorites.

33. Milky Way. The local galaxy, of which the sun is a member is saucer-shaped; it looks like a river of stars in the sky because it is seen on edge from the earth.

34. Nebula. A gaseous cloud in space; most are light years in diameter and are composed chiefly of hydrogen gas.

35. Nova. A star which becomes unstable, suddenly flaring up and then subsiding.

36. Orbit. The path that an object describes as it revolves around another object.

37. Perigee. The point in the orbit of an earth satellite that is nearest the center of the earth.

38. Periselenium. The point of a lunar satellite's orbit nearest the center of the moon.

39. Phases. The apparent changing of the shape of the moon or certain planets as the alignment between the moon or planet, the earth, and sun changes. Remember always that we see the moon and the planets only because the sun illuminates them.

40. Planet. A large body orbiting a star; there are nine large bodies circling our sun. They all shine by reflected sunlight.

41. Polaris. The North Star.

42. Poles. Those points where the axis of a body reach that body's surface.

43. Reflection. The rebound of light from an object.

44. Revolution. The motion of a body around a point or other body in space.

45. Rotation. The motion of a body around its own axis.

46. Satellite. A small object orbiting a larger object. In rare cases a large body orbits a smaller body, but only if the smaller body has a greater weight.

47. Star. A large body of gaseous material that radiates light and heat and has a sustained nuclear reaction.

48. Star cluster. A small star system containing a few hundred to a few thousand stars. Globular clusters, ball-like, are usually found on the outer fringes of the galaxy. Galactic clusters, open clusters, are usually found near the galactic plane.

A very unstable star which suddenly explodes.

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49. Supernova. A very unstable star which suddenly explodes.

50. Telescope. Instrument used in astronomy for viewing distant objects.

51. Twilight. That period of time when the sun is no longer visible in the sky above an observer's horizon, but when the light from the sun is still being carried above the horizon by refraction and the scattering effect that the atmosphere has on sunlight.

52. Universe. The whole concept of things and phenomena observed or postulated.

53. Zenith. The point in the sky above an observer's head; literally a plumb line from the center of the observer to space.

54. Zodiac. The name for the belt of twelve constellations through which the ecliptic passes.

SPACE-AGE GUIDE to the PLANETS

PLANET	MERCURY	VENUS	EARTH	MARS	JUPITER	SATURN	URANUS	NEPTUNE
Distance from the Sun (millions of miles)	36.0	67.2	92.9	141.5	483.9	886.0	1783.0	2791.7
Theoretical Minimum Time to Reach Planet from Earth	83 days	45 days		58 days	1 year, 8 months	3 years, 5 months	7 years, 5 months	12 years, 2 months
Diameter (miles)	3,100	7,700	7,927	4,200	85,750	71,150	32,000	27,600
Time to Complete One Orbital Revolution Around the Sun (measured in Earth time)	88 days	225 days	365.26 days	687 days	11 years, 314 days	29 years, 168 days	84 years, 7 days	164 years, 285 days
Length of Day (measured in Earth time)	88 days	225 days	23 hours, 56 minutes	24 hours, 37 minutes	9 hours, 50 minutes	10 hours, 14 minutes	10 hours, 49 minutes	15 hours, 40 minutes
Surface Gravity (measured in terms of 1 g on Earth)	0.35	0.88	1.00	0.38	2.64	1.17	0.92	1.40
Weight of a Man on the Planet if He Weighed 200 Pounds on Earth	70	176	200	76	528	234	184	280
Escape Velocity (miles per hour)	9,700	23,000	25,000	11,500	133,200	79,200	49,320	57,600
Temperature on Surface	–460° F. to 780° F.	–4° F. to 140° F.	–90° F. to 136° F.	–130° F. to 85° F.	–215° F. Average	–240° F. Average	–300° F. Average	–330° F. Average
Number of Moons	0	0	1	2	12	9	5	2

SPACE-AGE GUIDE to the PLANETS

PLANET	MERCURY	VENUS	EARTH	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
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of Day sured in Earth time)	88 days	225 days	23 hours, 56 minutes	24 hours, 37 minutes	9 hours, 50 minutes	10 hours, 14 minutes	10 hours, 49 minutes	15 hours, 40 minutes	16 hours
s Gravity sured in terms of g on Earth)	0.35	0.88	1.00	0.38	2.64	1.17	0.92	1.40	0.16
of a Man on the t if He Weighed 0 Pounds on Earth	70	176	200	76	528	234	184	280	32
Velocity s per hour)	9,700	23,000	25,000	11,500	133,200	79,200	49,320	57,600	22,000
ture on Surface	—460° F. to 780° F.	—4° F. to 140° F.	—90° F. to 136° F.	—130° F. to 85° F.	—215° F. Average	—240° F. Average	—300° F. Average	—330° F. Average	—345° F. Average
of Moons	0	0	1	2	12	9	5	2	0

ASTRONOMY DEMONSTRATIONS

Louisiana Arts and Science Center

DEMONSTRATIONS FOR USE WITH THE TRIPPENSEE PLANETARIUM

I. Day and Night

II. Seasons

III. Tides

IV. Phases of the Moon

V. Eclipses of the Sun and Moon

VI. Vocabulary

The Bibliographies on previous pages are applicable to these demonstrations.

Note: These demonstrations are given by our Louisiana Arts and Science Teachers in the individual classrooms whenever requested.

DEMONSTRATION: CONCEPT OF DAY AND NIGHT

Problem: What causes daytime and night?

Concepts:

1. The turning of the earth causes day and night.
2. The earth turns from west to east.
3. The earth makes one complete turn in one day or twenty-four hours.
4. The earth rotates on its axis.
5. The part of the earth facing the sun has daytime.
6. The part of the earth away from the sun has night.
7. A day beings at midnight only because it is convenient.
8. The earth also revolves around the sun.
9. Position of the sun in the sky differs throughout the day because the earth rotates.
10. The earth takes 365¼ days to revolve around the sun.
11. Every fourth year we add an extra day to February.

Procedure and Activities:

To introduce the demonstration, let the children point out the different parts of the Trippensee planetarium.

Vocabulary definitions:

1. Rotation. Either turn around yourself or bring a child to the front of the room and turn him around. Ask the class what is taking place. Then let all the children do it at their desks.

2. Axis. Put your finger on top of a child's head and ask him to turn around. Ask the children what your finger represents. When they understand that it is an imaginary line through the center of the earth, take other objects in the room (a pencil, an eraser, and so forth) and rotate them until the children see that anything which rotates, has an axis.

DEMONSTRATIONS FOR USE WITH THE TRIPPENSEE PLANETARIUM

I. Day and Night

II. Seasons

III. Tides

IV. Phases of the Moon

V. Eclipses of the Sun and Moon

VI. Vocabulary

The Bibliographies on previous pages are applicable to these demonstrations.

Note: These demonstrations are given by our Louisiana Arts and Science Teachers in the individual classrooms whenever requested.

DEMONSTRATION: CONCEPT OF DAY AND NIGHT

Problem: What causes daytime and night?

Concepts:

1. The turning of the earth causes day and night.
2. The earth turns from west to east.
3. The earth makes one complete turn in one day or twenty-four hours.
4. The earth rotates on its axis.
5. The part of the earth facing the sun has daytime.
6. The part of the earth away from the sun has night.
7. A day beings at midnight only because it is convenient.
8. The earth also revolves around the sun.
9. Position of the sun in the sky differs throughout the day because the earth rotates.
10. The earth takes 365¼ days to revolve around the sun.
11. Every fourth year we add an extra day to February.

Procedure and Activities:

To introduce the demonstration, let the children point out the different parts of the Trippensee planetarium.

Vocabulary definitions:

1. Rotation. Either turn around yourself or bring a child to the front of the room and turn him around. Ask the class what is taking place. Then let all the children do it at their desks.

2. Axis. Put your finger on top of a child's head and ask him to turn around. Ask the children what your finger represents. When they understand that it is an imaginary line through the center of the earth, take other objects in the room (a pencil, an eraser, and so forth) and rotate them until the children see that anything which rotates, has an axis.

3. Revolution. Ask two children to come up and demonstrate the difference between revolving and rotating. One can be the earth and one the sun. Then let the children rotate and revolve at the same time.

Now is the time to run the orrery (planetarium). Ask the children to observe the movements of all the parts and tell you which things are rotating and which are revolving.

After they are certain of the movements, discuss the fact that the earth rotates in one certain direction, from west to east. Establish the direction of north with the compass on the planetarium and ask two children to represent west and east; give them signs with E and W on them. After they are in the correct positions, bring another child up to be the earth. Ask him to rotate from west to east. When he has done so, let all the children do it at their desks.

Discuss the importance of the sun and the things it gives us. From this point, lead the discussion to light and dark and the way the sun affects our times of day. Let the children observe the planetarium in motion, especially watching the United States on the earth globe. Stop the planetarium in several positions until the children see that we are facing the sun at times and are away from the sun at others. This is a good time to explain the fact that New York has sunrise before we do, and that we see the sun before California does. Use a large world globe and hold it toward the sun on the planetarium, rotating it from west to east. It is usually easier to see why the eastern part of the United States has daylight first with a large globe.

To demonstrate the fact that the sun is in different positions throughout the day, have the children stand and ask them to face "sunrise" (east); then face "sunset" (west); then ask them if they can face "high noon." Many of them will realize the sun should be overhead and will look up at the ceiling. After discussing this fact, put the following drawing on the board and let the children put the sun in the correct position.

Sun at Noon

Sunset

Sunrise

Before talking about the number of days it takes to go around the sun, I ask them if they know why a new day starts at midnight. They understand the convenience if it is pointed out that they would come to school one day and go home the next if the day changed at noon.

When you discuss the number of rotations it takes for one revolution, always stress that one-fourth day, because the children will be able to see why we have Leap Year if they can add up four one-fourth's and get one whole day every four years.

This is a good place to show the children the planet chart and tell them that Jupiter has a ten-hour day, but a twelve-year revolution.

Now is the time to run the orrery (planetarium). Ask the children to observe the movements of all the parts and tell you which things are rotating and which are revolving.

After they are certain of the movements, discuss the fact that the earth rotates in one certain direction, from west to east. Establish the direction of north with the compass on the planetarium and ask two children to represent west and east; give them signs with E and W on them. After they are in the correct positions, bring another child up to be the earth. Ask him to rotate from west to east. When he has done so, let all the children do it at their desks.

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This is a good place to show the children the planet chart and tell them that Jupiter has a ten-hour day, but a twelve-year revolution.

Depending upon the time, you can use the planetarium and let the children come up and tell the time of day different countries are having when the motor is stopped.

From this demonstration it is suggested that you go right on to the one on the seasons.

Materials Used:

Trippensee planetarium
World globe
Planet chart
Signs: E and W
Chalk and chalkboard
If available, transparencies of Four Standard Time Zones and the International Date Line

DEMONSTRATION: CONCEPT OF THE SEASONS

Problem: What causes the seasons?

Concepts:
1. The earth revolves around the sun every 365¼ days.
2. The sun seems to change its position in the sky from season to season.
3. The tilt of the earth on its axis as it revolves around the sun causes periods of differing prevailing weather called seasons.
4. The earth moves one quarter of the way around the sun each three months.
5. The moving earth stays in orbit because of a balance obtained when the sun's gravity works against the earth's inertia.

Procedure and Activities:

Review with the children the words "revolve" and "axis." Introduce the word "tilt" and demonstrate with a world globe.

Run the Trippensee planetarium and ask the children to observe the tilt of the earth as it revolves around the sun. Stress the fact that the axis of the Earth points in the direction of the North Star as it rotates and revolves. Because of this, the United States is sometimes tilted toward the sun as it revolves and at other times, tilted away from the sun. It is a good idea to let a child take the world globe and revolve around an imaginary sun, keeping the axis pointed in the correct direction all the way.

When the children understand the position of the earth in its revolution, it is very easy for them to see why we have summer and winter. Let them decide when the North Pole has a lot of daylight and when it has a lot of night, by observing the moving planetarium. Ask them which countries are having winter and which are having summer when you stop the motor on the planetarium.

To show the difference in the sun's rays, use a flashlight. Shine it directly on the world globe or the chalkboard, showing the concentrated rays (summer). Then put it at an angle, showing the dispersed rays (winter). Since this is a very difficult concept to demonstrate, we reemphasize the tilt of the Earth and the way this affects the seasons in different parts of the world. These facts, along with the concepts of the various angles of the sun's rays, explain the difference in the heat of the sun during summer and winter.

The concepts of spring and autumn are demonstrated together, since the sun shines on both hemispheres equally. The children are able to see that both the North Pole and South Pole will have sunshine on March 21st and September 21st. Use the transparency of the seasons here to show equal hours of daylight and dark.

After discussing the four seasons and making it clear that the earth goes one quarter of its way around the sun every season, I run the planetarium and ask a child to tell me which season and whether it is day or night in a certain country when I stop the motor. Then I turn the earth in a half rotation and check to see if he realizes that just because it is now a different time of day, it is still the same season.

To demonstrate the balance between inertia and gravity, I generally ask a child to catch an eraser when I throw it to him. Explain that had he not caught it or the earth's gravity had pulled it to the ground, it would have kept on moving through space. The earth would do the same thing if it were not for the sun's gravity pulling the earth toward it. This is what keeps the earth in orbit around the sun. If the children understand this, I might mention that the moon stays in orbit around the earth because of the balance obtained between the moon's inertia and the earth's gravity.

Before closing the demonstration, I ask for questions from the class. We also list the months in the four seasons on the board.

Winter: December, January, February
Spring: March, April, May
Summer: June, July, August
Autumn: September, October, November

Materials Used:

Trippensee planetarium
World globe
Flashlight
Chalk and chalkboard
Transparency of the Seasons

DEMONSTRATION: PHASES OF THE MOON

Problem: What happens as the moon revolves around the Earth?

Concepts:

1. There are about twenty-nine and one-half days from one full moon to the next full moon.
2. The moon, shining by reflected light, appears to go through a series of phases during the month as various parts of its lighted half become visible to observers on earth.
3. The moon is kept in its orbit by the pull of the earth's gravity balanced by centrifugal force.
4. The moon rotates once on its axis during each revolution around the earth and, as a consequence, only one side of it is ever visible from the earth.
5. On any one night, the phase of the moon seen from any place on earth is the same.
6. The moon seems to move across the sky from east to west, due to the rotation of the earth. Close observation will also show that the moon moves from west to east, the moon's own motion around the earth.
7. The moon is 2,160 miles through the center; it is much smaller than the earth.
8. The moon is 240,000 miles away. A jet flying at 600 miles an hour could take us that distance in a little over two weeks. A modern spaceship will take just under three days.

Procedure and Activities:

To introduce the demonstration, review with the class the following words:

Gravitational force	Orbit
Rotation	Horizon
Revolution	Axis

Ask the children if they know how the movements of the earth affect their lives. They should talk about day and night, the seasons, and the tides. Ask them what they know about the moon, especially the size, shape, and regular appearance. From this discussion, lead the children to the concept of the changing shapes of the moon. Let them watch the Trippensee planetarium and observe the revolution of the moon and its relationship to the sun.

Discuss the light reflected on the moon and the area on the moon which receives light from the sun at any one time. Compare to the amount of light received by the earth as it rotates. Ask the students if the moon rotates as well as it revolves. Observe the orrery (planetarium) in motion again and then see if a child can revolve around an object (which represents the earth) the way the moon revolves. Bring out the fact that the moon keeps the same face to the earth, and is, therefore, rotating one complete time while it revolves once around the earth. Let the children again watch the planetarium to understand that though the earth only sees one side of the moon, the moon receives sunlight on all of its parts in one revolution. We only see a portion of the sunlit side of the moon, hence the phases of the moon occur.

Talk about the apparent changing shapes of the moon and show the chart on the phases of the moon or a transparency of the different positions of the moon. Let the children study the chart to visualize where the light from the sun is shining on the moon and how much the people on earth are able to see. Point out the quarter moon, full moon, and crescent moon phases; then run the planetarium in the various positions. Be sure the children understand that the moon is really in a different phase every night, but we have just named the four main phases: full moon, quarter moon, crescent moon, and the gibbous moon phases. Ask the children if everyone in the world is able to see the same phase we do. Also bring out the concept of the time it takes the moon to make one complete revolution. The term "lunar month" can be brought in. Some of the children might ask why some reference books say twenty-seven and one-third days while others say twenty-nine and one-half days. Explain to them that if the earth did not revolve, the moon would complete one orbit in twenty-seven and one-third days. But the earth is traveling around the sun, so the moon must travel an additional distance to make up for the forward progress made by the earth in its orbital path. The moon travels in the earth's orbit around the sun and this takes a little more than two extra days. Because this is true, it is twenty-nine and one-half days from one full moon to the next.

Discuss with the children the rising and setting of the moon. Let them demonstrate with a world globe the rotation and its effect upon the apparent motion of the moon across the sky. Explain to them that the moon rises in the east and sets in the west, just as the sun does.

To conclude the demonstration, let the children talk about the physical characteristics of the moon. Lead them to see that, as far as we know at present, the moon is a large, heavy ball of rock, has no water or air, and no living things. The pupils should realize there is little or no atmosphere on the moon.

Additional Activities:

1. Ask the children to look at a calendar which has the phases of the moon and to list the dates of the full moon. Have them explain why the date is not the same each month.

2. Suggest that a child find out what causes a ring around the moon and report to the class.

3. Ask a child to learn why, when the moon is a crescent, we can often see its dark part faintly.

Materials Used:

1. Trippensee planetarium
2. Chart of Phases of the Moon
3. Calendar with moon phases indicated
4. World globe

DEMONSTRATION: ECLIPSES OF THE MOON AND SUN

Problem: How do eclipses of the moon and sun take place?

Concepts:

1. An eclipse of the sun occurs when the moon's shadow falls on the earth. An eclipse of the moon occurs when the moon enters the earth's shadow.

2. An eclipse occurs only when the sun, the moon, and the earth lie on a straight line.

3. An eclipse of the moon occurs when the earth comes between the sun and moon. This is called a lunar eclipse.

4. An eclipse of the sun occurs when the moon is directly between the sun and the earth. This is called a solar eclipse.

5. Only a small portion of the earth is in shadow during a solar eclipse.

6. An eclipse may be partial or total or annular.

7. The orbits of the earth and moon do not lie in the same plane.

8. Astronomers are able to predict many years in advance when eclipses will occur.

Procedure and Activities:

To introduce this demonstration, let the children observe the Trippensee planetarium in motion and watch for the various positions of the moon in relationship to the earth and sun. After establishing the concept of reflected light from the sun, lead the children into a discussion of the effect of shadows. Use a flashlight and project a child's shadow on a screen or the blackboard. Explain that only part of the screen is covered by his shadow; the screen is larger than the boy. Relate this to the size of the earth and the shadow that the moon makes upon it. Run the planetarium until the moon is between the earth and the sun. Let the children see the

Additional Activities:

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From the concept of the solar eclipse, run the planetarium so that the earth is between the sun and moon. Let the children decide which celestial body is casting a shadow now. Once again compare the size of the earth and the moon and lead the children to see that the earth is casting a much larger shadow on the moon than the moon did upon the earth. This is the reason that half of the earth can see a lunar eclipse. Make sure that the children see that it is only the full moon position when a lunar eclipse takes place. This only happens, however, when the moon is in the earth's shadow and not above or below it, which is generally the case because we see the full moon once a month.

To emphasize the positions of the earth, sun, and moon during eclipses, let the children demonstrate the positions, either with a flashlight, globe, and tennis ball, or let the children pretend they are the sun, moon, and earth. Draw on the board the following sketch and explain that the moon does not always cause an eclipse because its orbit is not in the same plane as that of the earth. The moon's shadow only occasionally falls on the earth and the earth's shadow does not fall on the moon every month.

The moon's orbit is tilted slightly in relation to the earth's orbit. Therefore, conditions must be exactly right for an eclipse of the sun or moon.

Because the earth and the moon move so regularly, their positions may be determined far in advance of an eclipse. This is why we are able to watch for eclipses.

To conclude the demonstration, lead the children in a discussion of what conditions would be like in a place on the earth where the sun was totally eclipsed. Emphasize the importance of the movements of our earth, moon, and sun, and the effects produced by them.

Additional Activities:

1. Ask some of the children to discover when eclipses will take place this year by using a world almanac.

2. Let some of the children use a globe, flashlight, and moon-ball to test the idea they have about why there are not two eclipses between full moon and full moon. Orbit the moon-ball around the earth in such a way that it does not cause a shadow to fall on earth. Also, orbit the moon-ball so that it does not pass through earth's shadow.

3. Some of the children might want to illustrate an eclipse of the sun by doing the following:

Hold a small coin a few inches from one eye and close the other eye while looking at the lighted electric bulb on the ceiling of a room. The large bulb is far away and represents the sun. The small coin is close to your eye and represents the moon coming between the sun and the earth. You will observe that the small coin completely hides the light bulb on the ceiling and casts a shadow on your eye.

Materials used in Demonstration:

1. Trippensee planetarium
2. Flashlight
3. World globe
4. Chalk and chalkboard
5. Transparencies of the eclipses of the moon and sun

DEMONSTRATION: CONCEPT OF THE TIDES

Problem: What causes the tides?

Concepts:

1. The moon's gravitational force acting on the earth is the chief cause of the tides.

2. Gravitation is a force of attraction between any two bodies.

3. Gravitation is strongest when the bodies are close to one another.

4. A greater gravitational pull is exerted by a large body than by a small one.

5. The watery parts of the earth can move more freely than the solid parts and are thus more affected by the moon's gravitational pull.

6. The effect of the sun's gravitational force on the tides is much less than that of the moon.

7. Twice during each revolution of the moon, the sun and the moon are both in line with the earth and tides of unusually great range result.

8. Twice during each revolution of the moon, the sun and the moon pull at right angles to each other and tides of lesser range result.

Procedure and Activities:

To introduce the unit, discuss the fact that we are all traveling very rapidly through space. We do not fall off the earth because of a force called gravity. Draw on the board:

Gravity: The force that pulls you and all other objects of the earth toward the center of the earth is called gravity.

Use the transparency of the North Star to show gravity.

Hold a small coin a few inches from one eye and close the other eye while looking at the lighted electric bulb on the ceiling of a room. The large bulb is far away and represents the sun. The small coin is close to your eye and represents the moon coming between the sun and the earth. You will observe that the small coin completely hides the light bulb on the ceiling and casts a shadow on your eye.

Materials used in Demonstration:

1. Trippensee planetarium
2. Flashlight
3. World globe
4. Chalk and chalkboard
5. Transparencies of the eclipses of the moon and sun

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4. A greater gravitational pull is exerted by a large body than by a small one.

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7. Twice during each revolution of the moon, the sun and the moon are both in line with the earth and tides of unusually great range result.

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Gravity: The force that pulls
you and all other
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gravity.

Use the transparency of the North Star to show gravity.

To explain the force of gravitation, use the transparency of the solar system or one of the sun, moon, and earth.

Force of gravitation: Every object everywhere exerts a pull on every other object. Gravity is just one force of gravitation.

From these definitions go on to the concept of the importance of gravitation out in space. Emphasize the pull of the sun on the earth, thereby keeping the earth in orbit; the pull of the earth on the moon, keeping the moon in orbit. Demonstrate these concepts with the planetarium, letting the children observe the moon, earth, and Venus in their orbits.

Lead the discussion to the concept of distance and the resulting effects of gravitation, emphasizing the closer distance of the moon to the earth. Though the sun is larger than the moon, it will not exert as great a force because it is farther away.

Ask the children which is easier to move, solid or liquid? Lead them to see that the waters of the earth will be pulled more easily than the land.

Run the planetarium again and ask the children to tell you what object in space will pull on the waters of the earth. When they agree upon the moon, show them a world globe and talk about oceans, rivers, lakes, and so forth. In a discussion of the tides, be sure they understand that all bodies of water rise and fall, but it is not so noticeable in the smaller ones.

Ask the children to tell you some things they know about shorelines: tide marks, seashells, marks on dock pilings, and so forth. All these signs show how high the tide has been.

Run the planetarium until the moon is between the sun and the earth. Introduce the words "flood tide" (rising tide) and draw on the board:

Ebb tide or Low tide

Sun Moon Earth

Flood
tide

Water in the oceans is pulled toward the moon and the sun. Water on the other side of the earth is left in a bulge. The earth is attracted by the moon, also, and is "pulled away" from the water. The "ebb tide" is the receding water as the tide goes down.

The following concepts can be introduced with the above drawing and the planetarium:

1. High tides take place in the waters of the earth nearest the moon and in waters farthest from the moon.

2. Low tides occur at the places from which the waters of the earth are being pulled away.

3. Because of the earth's rotation, there is a change in tides

Force of gravitation: Every object everywhere exerts a pull on every other object. Gravity is just one force of gravitation.

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1. High tides take place in the waters of the earth nearest the moon and in waters farthest from the moon.

2. Low tides occur at the places from which the waters of the earth are being pulled away.

3. Because of the earth's rotation, there is a change in tides every six hours. Illustrate this with a globe or planetarium to show the waters are either toward the moon or on the opposite side of the earth, high tide position.

To explain the spring tides, run the planetarium so the moon and sun are in line with the earth. Refer to the drawing on the board.

To explain the neap tides, run the planetarium so that the moon and sun are at right angles to the earth. Draw the following on the board:

Moon

Sun

Earth

Neap tide

Because the sun and moon are pulling at right angles to the earth, the waters of the earth will have two forces pulling on them. Because the moon is closer than the sun, its gravitational force is stronger, so the tides will be higher toward the moon but not quite as high as the spring tides. The neap tides occur twice a month as do the spring tides.

Run the planetarium and question the children about the various positions of the moon and its effect upon the tides. It would be well to use the world globe again and demonstrate rotation of the earth to emphasize the reason we have changing tides every six hours, letting the children use the globe or letting them represent the earth, moon, and sun.

To conclude the demonstration, the children could draw their own diagrams or other pictures which relate to the tides.

Materials used:

Trippensee planetarium
World globe
Chalk and chalkboard

Additional Activities:

1. Suggest that children find out why the tidal range is so much greater at some places, such as the Bay of Fundy, than at others.

2. Have the children read to learn how tides are important to seamen and to people who live near the ocean shores.

3. Suggest they make a bulletin board or scrapbooks of pictures showing different shorelines or how the tides affect our lives.

4. To better understand the effects of a high tide:

   Fill a pan about one-third full of dry sand. Arrange the sand so that it slopes very gradually from high on one side to very low on the other side. About half-way up the slope, make a small "dock" of cardboard with sticks to hold it up.

   Now pour water gently into the part of the pan where there is very little sand. This water is the "ocean." Continue moon and sun are in line with the earth. Refer to the drawing on the board.

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Additional Activities:

1. Suggest that children find out why the tidal range is so much greater at some places, such as the Bay of Fundy, than at others.

2. Have the children read to learn how tides are important to seamen and to people who live near the ocean shores.

3. Suggest they make a bulletin board or scrapbooks of pictures showing different shorelines or how the tides affect our lives.

4. To better understand the effects of a high tide:

   Fill a pan about one-third full of dry sand. Arrange the sand so that it slopes very gradually from high on one side to very low on the other side. About half-way up the slope, make a small "dock" of cardboard with sticks to hold it up.

   Now pour water gently into the part of the pan where there is very little sand. This water is the "ocean." Continue to pour until the water is part way up the pilings of your dock.

Then begin to dip the water out. Continue to dip until almost all the water has been removed. How can you till how far up the "tide" came?

VOCABULARY FOR DEMONSTRATIONS OF THE CONCEPTS OF DAY AND NIGHT, THE SEASONS, PHASES OF THE MOON, LUNAR AND SOLAR ECLIPSES, AND THE TIDES

I. Day and night demonstration

1. A.M. Before noon; the time from midnight to noon.

2. Axis. An imaginary line that passes through an object and about which that object turns.

3. Midday. Noon.

4. P.M. After noon; the time from noon to midnight.

5. Revolution. Motion of a body in a curve around some other object.

6. Rotation. The motion of a body around its axis.

7. Time zone. One of the twenty-four regions into which the earth is divided. Each zone has a standard time that is used by all places within that region.

II. Demonstration of the seasons

1. Equator. An imaginary circle around the earth, halfway between the North Pole and the South Pole

2. Gravitation. The force of attraction between any two bodies. It is strongest when the two bodies are close together and weakest when they are far apart. The larger the body, the greater the force of attraction.

3. Northern Hemisphere. The half of the earth that is north of the equator.

4. Orbit. The path of any heavenly body about one or more other heavenly bodies.

5. Revolution. Motion of a body in a curve around some other body.

6. Southern Hemisphere. The half of the earth that is south of the equator.

7. Tilt. To incline or tip.

III. Phases of the moon demonstration

1. Gibbous. A shape of the moon appearing between the quarters and the full moon.

2. Horizon. The line where the earth and sky seem to meet.

3. Lunar month. The length of time needed for the moon to make one complete orbit around the earth, about twenty-nine and one-half days.

4. Phase. The apparent shape of the moon; that amount of the lighted part of the moon we see.

Review vocabulary used in this demonstration:

1. Axis. An imaginary line that passes through an object and about which that object turns.

2. Gravitational force. The force of attraction between any two bodies.

3. Orbit. The path of any heavenly body about one or more other heavenly bodies.

4. Revolution. Motion of a body in a curve around some other body.

5. Rotation. The motion of a body around its axis.

IV. Demonstration of eclipses

1. Corona. Ring of light around the sun. This pearly-white light always surrounds the sun, but we see it only during a total eclipse.

2. Eclipse. The darkening of one heavenly body by the shadow of another. In a total eclipse, the whole body is out of view. In a partial eclipse, part of the body is visible. A solar eclipse occurs when the moon lies in a direct line between the sun and earth. A lunar eclipse occurs when the moon passes through the earth's shadow. At this time the earth lies between the sun and moon.

V. Tides demonstration

1. Ebb tide. Receding water.

2. Flood tide. Rising water.

3. Gravity. The force that pulls you and all other objects of the earth toward the center of the earth.

4. Gravitational force. The force of attraction between any two bodies.

5. Neap tides. Lower than usual tides produced when the sun and moon are at right angles.

6. Spring tides. Higher than usual tides produced when the moon and sun are in line.

7. Tidal range. The difference in level between the highest and lowest tides.

INITIAL VISIT TO ACQUAINT THE CHILDREN WITH PLANETARIUM

The following material is presented in all of the upper elementary classrooms in the parish in order to acquaint the children with the new planetarium and the things they will see there when it is completed. The Liaison Teacher from the Louisiana Arts and Science Center takes visual aids into the classroom and does the presentation.

I. Introduction

A. What the Arts and Science Center is and where it is located.

B. What the teacher's job is with the planetarium and how she will work with the children.

II. Description of the planetarium

A. Physical description of the instrument:
Weighs two and one-half tons; twelve feet tall; has eleven motors; and 155 projectors.

B. The building: Location is right behind the Arts and Science Center; domed roof which represents the sky; location of the instrument; seats 250 people; total cost of building and instrument will be about $365,000.

C. What the planetarium can show us: 9,000 stars in their correct color, magnitude, and location; the five naked-eye planets Mercury, Venus, Mars, Jupiter, and Saturn; the constellations; meteor showers; a Nova; auroral lights; eclipses; and precession--how the sky will look in, say, 13,000 years from now; latitude change, simulating a journey to other latitudes; the birth and death of a comet; celestial navigational aids; sunrise and sunset; movements of the solar system.

Note: Be sure the children understand the difference between the planetarium and the observatory.

III. Topics discussed

A. Observation of the constellation by man through the ages and the myths and legends which have grown up about the stars.

Today the Astronauts learn all the constellations in order to orient themselves when above the earth's atmosphere. They use a planetarium instrument like the one we will have in Baton Rouge to study the stars.

B. Discussion of the star globe and why we can make a globe of the sky when we know that the sky really goes on and on. The following drawing can be put on the board.

North star

The sky is
like a
cover

sky

Earth

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like a
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sky

Earth

sky

People in the Southern Hemisphere have a sky, too.

The children are told that they, too, will get the feeling that they are out in space when they come to visit the planetarium, just as our Earth is whirling out in space.

C. Satellites and what they can do: Take pictures, predict weather, relay Television and radio signals.

D. Bring in current events in our space program. Pictures of the astronauts and pictures taken by the astronauts, news clippings such as the ones concerning the meteor which exploded over the midwest or the Cassius Clay fight which was transmitted by satellite all relate to the study of space and the new planetarium.

In closing the presentation, ask for questions and try to remember the ones about the universe in order to give our astronomer some indication of the children's interests.

Visual Aids Used:

Celestial globe showing the constellations
Pictures:
- Louisiana Arts and Science Center
- Planetarium instrument
- Astronauts in space walk
- "Miss Sam" - astrochimp
- John Glenn
- Tiros II weather satellite
- Planet chart

Transparencies:
- Leo the Lion
- The Big Dipper
- The North Star
- The Solar System
- The Earth as the Center of the Solar System

Note: The visual aids used are changed from time to time and not all are used in every class.